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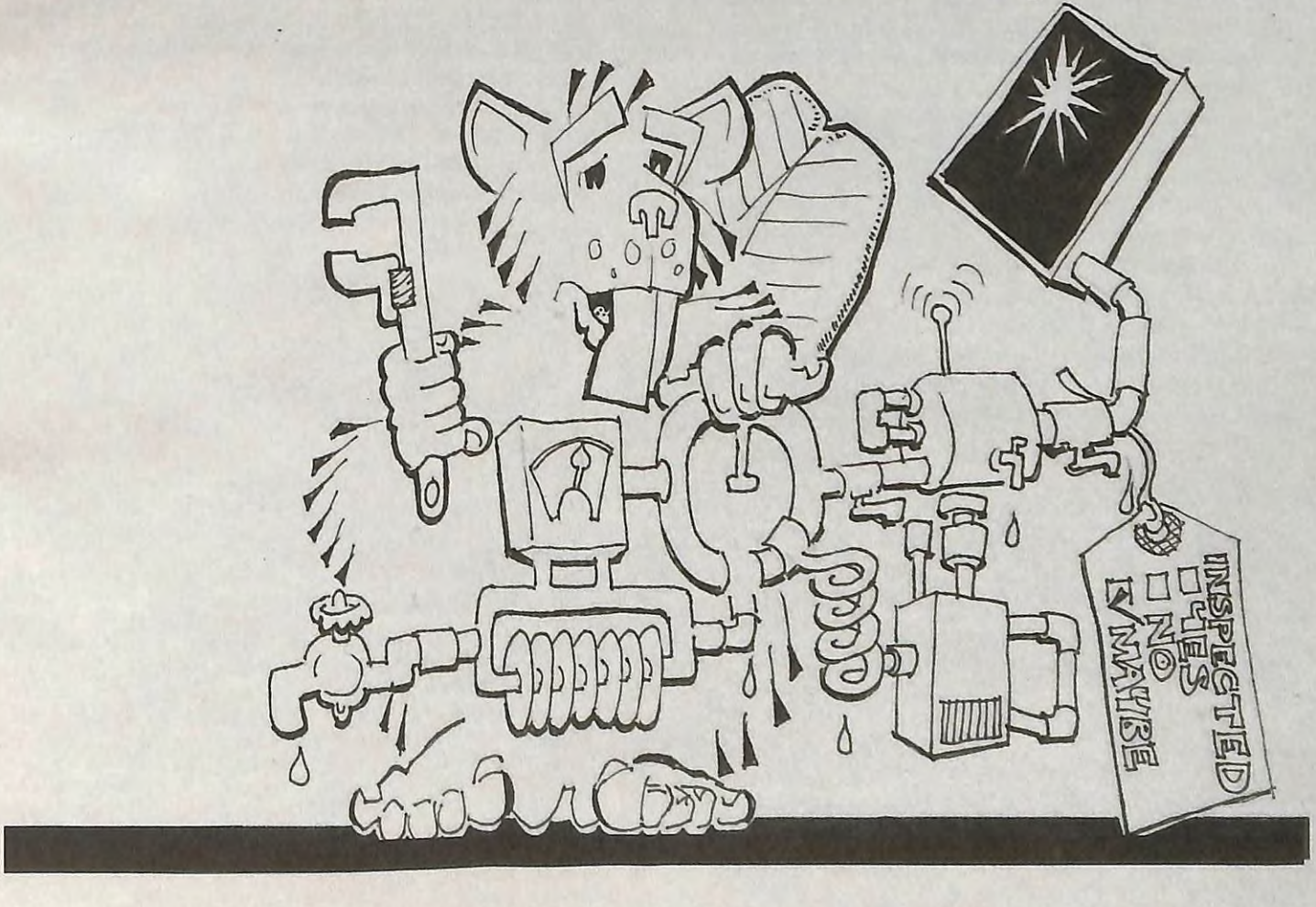
Solar Domestic Hot Water Systems



From The Editor ...

Research and innovation are the lifeblood of the new world. In a short time we have seen great technological evolutions. Today we rely on technologies that were a figment of a science fiction writer's imagination only a generation ago. So much we see and use today seemed too fantastic and unbelievable only a few years ago.

Innovations come in all walks of life. Whether it's the humble paint roller or the ubiquitous Blackberry, we see Canadian inventions around the world. Some were developed and refined here while others had to be developed elsewhere because we often lack the conviction and self-confidence in ourselves as a nation. We seem to be content to let others take the risk of presenting new ideas. It is natural to be afraid of anything new.

But it is important to recognize that technological progress doesn't happen from thin air. It gets built on a foundation of creative scientific innovation. It relies on a culture open to new ideas. So it is disheartening to see so little support given to research in this country.

In recent years we have seen a governmental culture that is deliberately cutting back on support for activities that might generate ideas and evidence that is contrary to their ideological dogma. The corporate sector itself is has been reluctant to invest in research.

A culture that encourages research and innovation has an impact on all walks of life. And it goes without saying that it also has implications on the construction site.

Today I see computers and Internet hook-ups on many job sites. It's become as natural as a cell phone and the plethora of specialized power tools. But just using the latest gadgets will not resolve all problems or keep mistakes from happening. There are always stragglers that don't get it, or who don't understand how to take advantage of the latest knowledge.

It is disheartening to find the same lack of openness to innovation and even understanding of basic science among some of the regulatory folks. Regulators generally react to issues – regulations are implemented to set the minimums that must be met and to deal with laggards. In some cases, regulations are drafted to move an industry in a direction desired for public policy reasons – to implement community goals.

In theory, regulators are open to innovation and new technologies as long as they meet public policy objectives. Unfortunately, reality can be very different. It's one thing to set goals and objectives and write regulations. It's another to see meaningful outcomes.

I've encountered a number of instances where inspectors have ignored the intent of the regulations they are enforcing, or rejected details or technologies largely because of their personal biases, prejudices or simply lack of understanding of basic principle or comfort with new ideas.

To achieve the objectives requires knowledgeable participants. It doesn't always happen. The requirement for expensive and unnecessary double-walled heat exchangers for solar water heating systems in many BC jurisdictions is just one such example. Every builder and building official (since it's a double edged sword) could generate a list of issues where the lack knowledge or self-confidence creates problems and in fact defeats the ultimate objectives.

It would be nice to see more support for innovation and research along with education so that it would be easier for all players to understand and properly implement new technologies without roadblocks or creating other problems. But then maybe that would be living a dream world.

Richard Kadulski
Editor

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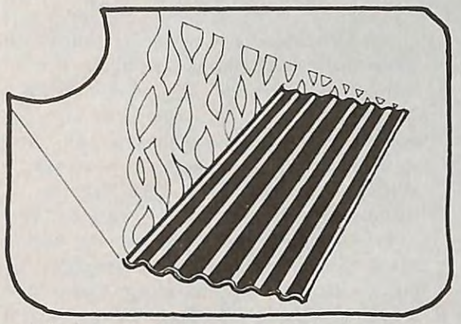


Solar Domestic Hot Water Systems

Solar energy is the most abundant and environmentally benign energy source we have, but we don't take enough advantage of it. A properly designed, well-insulated building can get a significant portion of its heat requirements by passive solar heat gains.

As we build more energy efficient homes, with very small heating loads, the energy for heating hot water becomes an important consideration. Domestic hot water is the second-highest energy cost in the typical household. For very low energy homes, it can be the biggest single energy expenditure.

This is where active solar systems come into play. Solar DHW is probably the single most cost effective and simple technology in our renewable energy system. Depending on location and occupancy, solar water heating can reduce domestic water heating costs by as much as 65%.

Solar domestic hot water collectors are traps that capture sunshine. They are very simple yet effective. Sunlight strikes the solar collector and heats a dark coloured, typically metal, absorber underneath a glass cover. This heat is transferred to a fluid that is pumped through the collector.

The heat exchange fluid is a non-toxic antifreeze solution (typically propylene glycol and water). The warm solution transfers heat to the water in a storage tank through a heat exchanger. The water is heated repeatedly in this fashion until the solar tank is hot. A high temperature rise through a single pass in the collector is not efficient - the most efficient systems have a small temperature rise each pass.

Some systems, especially in milder climate zones, are drain-back systems. In these, the heat transfer fluid is regular potable water rather than an antifreeze solution. In a drain-back system, freeze protection is taken care of by draining the water in the collectors back to a separate holding tank. Thus, there is no water in the system to worry about when night-time freezing temperatures are experienced which could create problems.

Typically, the solar water heating system is a preheater for the conventional water heater. Any heat collected reduces the amount of energy needed to provide hot water. In most cases the solar can provide about 50% of the home's hot water needs. How much depends on the location, water needs and usage patterns as well as time of year.

In the summer, solar energy can provide a significant portion of the hot water, while in the middle of winter, it will be a small fraction, at best preheating incoming water by a couple of degrees.

Adoption of Solar Energy Technologies

In the late 1970s an awareness of our energy systems came to the forefront as a result of the first energy crisis brought on by the actions of oil producers. We became aware again about the potential of renewable energy. It became abundantly clear that some of our energy needs could be met through low-tech approaches.

Due to the absence of commercial products, many started take advantage of solar with do-it-yourself approaches. In 1979, BC Hydro even commissioned a group of Vancouver consultants (Roger Bryenton, Ken Cooper, and Chris Mattock and Terry Lyster) to prepare an illustrated do-it-yourself guide to constructing solar water heaters. The book titled *Solar Systems in BC: a step by step guide to help you build your own solar water heater* was published in 1979. It became the textbook for countless hands-on workshops. In 1980 a modified version was published under the title *The Solar Water Heater Book: Building And Installing Your Own System* and was sold throughout the country.

Water Heating Facts

- 25% of an average Canadian household's energy bill goes to heating domestic hot water. This increases as the house becomes more energy efficient.
- A solar water heating system can save 50-75% of the water heating cost
- A solar water heating system can reduce an average household's greenhouse gas emissions by up to 2 tonnes a year

CSA F379.1-88 Requirements

The CSA F379.1-88 standard allows the use of both single and double-wall heat exchangers:

Single wall heat exchangers in Drainback and Closed-loop systems require:

- The use of a non-toxic heat transfer fluid (inclusive of all additives) or potable water in the heat transfer loop at the time of installation. Material Safety Data Sheets (MSDS) for the specific product(s) being used may provide guidance for determining toxicity levels;
- A stainless steel tube heat exchanger;
- The installation of a backflow preventer in accordance with CAN/CSA-B64.3, which is a dual-check Valve Type, with Atmospheric Port (DCAP) at the inlet to the solar hot water system;
- Other safeguards such as a pressure gauge, pressure relief valve and maximum working pressure as specified in CAN/CSA-F379.1-88.

Double-wall heat exchangers:

- Require the use of a heat transfer fluid that is non-toxic, or toxic with a Gosselin toxicity rating of 2 or less (inclusive of all additives);
- Do not require the use of a backflow preventer unless a make-up water connection is provided to the heat transfer loop;
- Require other safeguards such as a pressure gauge and a visible means of leak detection as specified in CAN/CSA-F379.1-88.

Heat Exhagers in Solar DHW Systems

Solar water heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid used to heat water.

Heat exchangers can be made of steel, copper, bronze, stainless steel, aluminium, or cast iron. Solar heating systems usually use copper, because it is a good thermal conductor and has greater resistance to corrosion.

A single-wall heat exchanger is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water.

Double-wall heat exchangers have two walls between the two fluids. Double walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol (antifreeze), and are often required as a safety measure in case of leaks, helping ensure that the antifreeze does not mix with the potable water supply.

Although double-wall heat exchangers increase safety, they are less efficient because heat must transfer through two surfaces rather than one. To transfer the same amount of heat, a double-wall heat exchanger must be larger than a single-wall exchanger.

Despite this one official has told us that "until the last five years, double-walled exchangers with leak detection did perform less efficiently than their single walled counterparts, but the modern double-walled exchangers with leak detection are practically the same efficiency now." The cost difference between the two was described to us by solar contractors as "hardly significant". But this is not what the industry has been telling us, and is certainly underscored by price quotes.

It is hard to know how many solar water heaters were built following the plans, or how many are still in operation. However, it is clear that these documents filled a need, and provided useful information. There is no evidence of widespread contamination or other disastrous events as a result of the installation of do-it-yourself solar water heaters.

In the early 1980s the energy crisis seemed to have gone away. North American energy prices fell, so we were lulled into a false sense of security. The traditional energy suppliers were, of course, not unhappy, and did nothing to encourage solar applications.

Today it is the awareness of the impact we are having on the environment and the climate change implications that have re-awakened interest in solar energy. Today, the solar industry is growing, more so in other parts of the world, but even in Canada a small group of companies is soldiering on. The do-it-yourself option is not necessary to access solar systems.

Most of these systems were installed in the absence of well-defined regulations.

Regulatory Issues

Today the building code includes references to solar water heating systems and there are CSA standards to deal with solar systems. Incentive programs, such as *ecoEnergy* and their provincial and utility counterparts have included solar as an option.

In some areas, it is mandatory to make houses solar ready by installing conduits to facilitate future solar panel installation. So one could expect that there are fewer obstacles to the implementation. However, seemingly higher walls to prevent widespread implementation of solar are being erected by the bureaucracy.

I don't know if the plumbing and building regulators are in cahoots with the fossil fuel industry, or if they have really fallen victim to the legal fraternity preaching liability concerns and risk avoidance. However, they have become creative in setting roadblocks to the adoption of solar DHW.

The major concern seems to be one of possible contamination of the water system.

The code requires that connections to a potable water system need backflow devices

to prevent non-potable water from entering the water system. The normal way this is done is by the installation of backflow valves.

Plumbing officials in BC have interpreted the code to mean that solar water systems must have a double-walled heat exchanger and positive leak detection. This means a much more expensive system with a lower efficiency. The rationale provided is that the code referenced CSA standard that deals with backflow preventers identifies solar energy units as being a severe hazard.

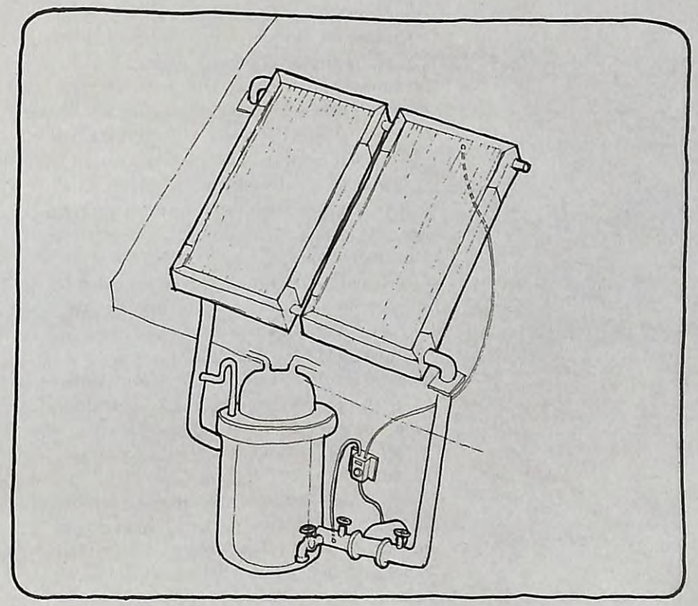
The reality is that double-walled heat exchangers are not as efficient and add cost to the system. Currently, solar companies in the Vancouver area are quoting $8,000 to 9,000 for a typical installed cost of a two-panel domestic solar water heating system for a house. Some are no longer pursuing domestic water heating systems because the uptake is so small at these prices.

Some jurisdictions still don't understand solar, so are asking for multiple permits for various parts of the system. Some of the concerns are a result of ignorance.

One solar installer has developed his own, in-house spreadsheet to try and track down the requirements that can include: plumbing, electrical and building permits, as well as professional structural and mechanical design. Yet some have "solar ready" requirements. He found that within the Vancouver region, only 3 jurisdictions (out of 25) expressed the opinion that they would support solar and try make it happen.

Some said they thought solar was great but still required protective measures, some were indifferent and others were outright negative, suggesting that they would need to approach every case individually and they would give no ideas what costs would be incurred until a specific permit application was made. The implications of such as attitude are disturbing to say the least – it's like telling you "we're not going to tell you what you need to provide, and how much we're going to charge for your next building permit until we see your plans in our office." How many houses would you be able to build in that environment?

One official told a contractor that solar was useless and that as far as he was concerned there should be no such thing as "solar ready" homes in the Lower Mainland area of BC. Any thoughts on how that municipality would look upon an application for a solar domestic hot water system?



Especially since in BC the authority having jurisdiction over code application is the local building official, even though the province sets out the code.

We have seen a number of jurisdictions disregard even basic building code provisions through their administrative practices. Variable regulatory interpretations have become such a concern that the provincial government is setting up a new process to set out code interpretations with teeth that will curb some of worst abuses of the process.

Responsible professionals and regulators rely on standards as a back-up to their professional evaluations. Solar water heating systems are covered by CSA Standard F379.1 (*Packaged Solar Domestic Hot Water Systems*) which covers the performance, durability and safety of packaged solar domestic hot water systems that use liquid-to-liquid heat transfer and liquid heat storage media suitable for year-round use.

The BC Building and Safety Policy Branch issued an interpretive bulletin pointing out that by code, solar domestic hot water systems must conform to CSA-F379.1-88 and be installed in conformance with CAN/CSA-F383–87 (*Installation Of Packaged Solar Domestic Hot Water*

Systems). However, the Building Code does not require certification with these standards.

Current BC Building Code requirements do not require any additional safeguards for solar domestic hot water systems beyond those required by the CSA standards, unless a make-up water connection is made directly to the solar heat transfer loop. If a direct connection is made to provide make-up water to the solar heat transfer loop that contains anything other than potable water, this direct connection needs be protected in accordance with Section 7.6.2 of the BCBC.

Despite this clear information, a number of jurisdictions have flat out stated that they will not abide by the minimum provisions of the code, but insist on double-walled heat exchangers. They are justifying ignoring these provisions by saying that the interpretive bulletin is an opinion piece without any legal weight behind it (no matter that it was issued by the arm of government that administers the building code).

The city of Burnaby states plainly "although CSA F379.1-88 allows the use of both single- and double-wall heat exchangers, the building department only accepts double-walled heat exchangers with leak detection".

The city of Vancouver, through their Waterworks By-law requires that "new or replacement heat exchangers must be double-walled with an integrated leak path, and be designed and tested for use with potable water systems in conformance with the International Association of Plumbing and Mechanical Officials (IAPMO) Material and Property Standard IAPMO PS 92-2008a" even though they require conformance with the CSA solar domestic hot water standards.

They further state that packaged systems that are certified to F379.1-88 but that do not have a double-walled heat exchanger with an integrated leak path have to be modified to include a double-walled heat exchanger with an integrated leak path. However, the city will accept the use of heat exchangers that are not CSA-certified provided they are either certified to IAPMO PS 92-2008a, or certified to UL(C) 207, where the unit is marked as suitable for installation in a potable water system.

The fluid in a solar system is normally at a much lower pressure than the potable water system. In the unlikely event of a leak the pressure would be from the pressurized potable water system toward an extremely low-pressure zone (the heat transfer fluid - which is not pressurized). In the unlikely event there were to be contamination, the back-flow preventer would stop contamination of the water system.

Other jurisdictions in BC are taking the lead from the larger cities, and make similar demands. Double-walled heat exchangers are the major concern, but not the only one. Some of the municipalities are going overboard on their requirements, past the nominal plumbing permit. They are requiring:

- Structural engineering calculations and mounting details for the collector panels (including professional site review and certification of the structural installation). However, a typical, glazed, flat plate collector may weigh about 5 pounds per square foot, compared to a skylight that may be about 6 pounds per square foot. Structural design that falls within defined limits of Part 9 of the building code does not require structural engineering (and that includes skylights) so it is not clear why solar collectors need additional engineering.
- Electrical contractors to lay (low voltage) sensor wire.
- Mechanical engineers to do system design and site review (including professional site review and certification of the installation).
- Special "solar storage tanks" instead of allowing the use of a standard electrical hot water tank for the storage.

Drainback systems that are filled with potable water and have no other substances added could be deemed to represent the same level of hazard as a domestic hot water heating system boiler.☼

Oops

Recently we've run through a patch of turmoil. Acquisition of a new computer and the movement of files from one to the other led to some loss of data as an older backup file got used. This led to some regular subscribers getting repeated renewal notices, even though they had dully renewed their subscriptions. We're correcting all entries as we become aware of them, and apologize for the inconvenience.

The January 2011 issue was put through under tight deadline pressures, and a few typos and errors got through the review process. A gold star is due to everyone that spotted the errors. And our apologies for any confusion.

The Cost of Net Zero Housing

Talk of high performance energy efficient housing seems to automatically generate the question of how much? The move towards net zero homes faces challenges, especially about the incremental costs of the systems and technologies needed to achieve such high performance levels.

CMHC's EQuilibirum projects are showcasing technologies that will achieve net zero or nearly net zero homes, often with high cost premiums. If you throw enough money at something you can achieve wonders.

Some of the builders involved with these demonstration homes are not only finding genuine interest from the public, they are getting orders for houses built to these standards. They are also finding creative ways to show that extremely high performance, energy-efficient homes are cost effective and achievable today.

Brian Hayashi of NexBuild Construction was project manager for the CHBA Central Interior and Thompson Rivers University 2010 Green Dream Home – the EQuilibrium home in Kamloops, BC. He has found a way to explain to customers that these high performance homes can actually be affordable today.

He took one of their common stock plans – a 1729 sq.ft. house – and priced it if built to different construction standards. He is able to show prospective customers that the net zero or near net zero house can actually be cheaper than a standard code built house which typically achieves an EnerGuide rating of 72 when built according to prescriptive code requirements. We've summarized their numbers in the attached table, which was prepared as part of a consumer show display.

	Code-Built EnerGuide 72	Built-Green Platinum Energuide 82	Near Net Zero EnerGuide 90	Net Zero EnerGuide 100
Basement Entry 1729 sq. ft.	$ 275,000.00	$ 285,000.00	$ 305,000.00	$ 350,000.00
Grants	0	($1,500)	($ 3,500)	($ 3,500)
Total construction cost to build (not including land)	$ 275.000.00	$ 283,500.00	$ 301,500.00	$ 346,500.00
Down payment	$ 13,750.00	$ 14,175.00	$ 15,075.00	$ 17,325.00
Mortgage amount 5% down	$ 262,250.00	$ 269,325.00	$ 286,425.00	$ 329,175.00
Mortgage payment 4.19%	$ 1,401,27	$ 1,452.22	$ 1,554.13	$ 1,783.43
Monthly light & heat	$ 250.00	$ 125.00	$ 75.00	0.00
Insurance	$ 66.67	$ 66.67	$ 54.17	$ 54.17
Monthly cost	**$ 1,717.94**	**$ 1,642.89**	**$ 1,683.30**	**$ 1,837.60**
Annual cost	**$ 20,615.24**	**$ 19,726.64**	**$ 20,199.56**	**$ 22,051.20**
Costs are based on assumed operating costs and lifestyles. They represent current values in the Central Interior of BC.				

NRCan's ENERGY STAR for New Homes Initiative

ENERGY STAR for New Homes Technical Specification - Ontario

The Office of Energy Efficiency (OEE) of Natural Resources Canada (NRCan) has promoted the international ENERGY STAR symbol in Canada and monitored its use since 2001. In 2005, ENERGY STAR for New Homes (ESNH) was launched in Ontario (initially as a pilot).

Due to the success of the ENERGY STAR for New Homes initiative in Ontario and the increasing number of players involved, NRCan was asked by all ESNH service organizations and a number of other stakeholders to establish a common set of technical specifications for ENERGY STAR for New Homes for Ontario. The goal of this work was not to change or increase the ESNH performance levels, but to "standardize" the requirements for stability and predictability for all.

To achieve the objectives established for this project, the licensed ENERGY STAR for New Homes service organizations operating in Ontario worked closely with NRCan to develop a draft common specification. NRCan published the proposed specification for public consultation in December 2009 and invited all program participants to provide feedback. Approximately 300 comments were received and addressed through that public consultation. NRCan thanks everyone that participated in this process and contributed to its success.

While working all of the existing specifications into one amalgamated "common spec", the intent of this project was to enable builders to continue using the prescriptive packages that they currently use to enrol houses (avoiding unnecessary change). The project has been successful in this regard, making a seamless introduction of the "common spec" possible. Thus, all builders in Ontario should be readily able to transition immediately to the new specification.

The resulting ENERGY STAR for New Homes Technical Specification – Ontario is now available. This new specification will be available to all ENERGY STAR for New Homes participants in Ontario from now until the next generation of the ENERGY STAR for New Homes program requirements have been finalized. The new requirements will be launched in conjunction with the Ontario Building Code requirement increases planned for implementation in January 2012.

ESNH Technical Advisory Committee (TAC)

In response to general feedback received on ENERGY STAR for New Homes, a national industry-led ENERGY STAR for New Homes Technical Advisory Committee (TAC) was created in 2009. The TAC's primary mandate is to provide advice and recommendations to Natural Resources Canada (NRCan) on the ENERGY STAR for New Homes initiative regarding ongoing technical and operational issues. For example, the TAC provides input into clarifications that are requested by industry and/or NRCan as a result of the day-to-day delivery of the program.

There are 9 to 12 voting members of the TAC which represent a range of user groups (builders, energy advisors, and service organizations) and geographic locations. Membership is adjusted annually so that the TAC members represent program stakeholders from all regions as the program continues to expand. NRCan's role in the TAC is to act as the secretariat of the committee and provide related support. NRCan also helps by engaging subject matter experts when required and at the request of the TAC.

For further information about ENERGY STAR for New Homes, visit the web site at:
www.newhomes.nrcan.gc.ca

R-2000
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Great Canadian Reno-Demo Update

After a seemingly endless period, visible progress is being made and insulation is well underway.

To achieve high insulation levels and better air tightness, we're using a combination of approaches. The exterior walls use the *CodeBord*® Air Barrier System by Owens Corning. This system has an external air barrier system to achieve continuity and minimize air leakage. It relies on 2" thick CodeBord extruded polystyrene insulation installed on the exterior of the sheathing and sealing all joints.

The system relies on gaskets applied over exterior framing members at joints between boards, corners, outside edges, and around openings. The insulation is then securely fastened to provide a continuous air barrier. An alternate detail is to rely on a butyl tape applied to seal joints from the surface.

House exterior prior to installation of wood strapping for rain screen: 2" thick CodeBord® rigid extruded polystyrene insulation taped at all joints to create exterior air barrier. Siding on lower level is remaining part of an earlier renovation 15 years ago. The siding was installed on strapping over 1½" extruded polystyrene sheathing.

Interior view of upper level – spray foam insulation forms part of the air-barrier. Two types of spray foam insulation are being used in adjoining rafter spaces over the shower area of the bathroom – the closed cell two pound Icynene which is being used throughout, and half-pound Icynene. Rafters have moisture pins installed – we will be monitoring the moisture content. Traditional polyethylene vapour barrier is not being used anywhere in the house.

Because this is a renovation, and we are dealing with original shiplap sheathing and irregular framing, we've had to opt for the surface-applied butyl tape. Wood strapping is applied over the insulation to form the rainscreen, to which the siding will be applied.

The CodeBord not only provides the principal air barrier but also R-10 insulation across the framing, reducing thermal bridging. It also acts as the weather barrier.

The upper floor in this older house has the original vaulted ceilings framed with 2x4 rafters. The rafters have been furred to provide a six-inch depth for insulation to enable the code minimum for insulation of R-28. The small dimensions of the house and limited headroom made it difficult to make a deeper cavity for insulation. The insulation used is a two-pound closed cell foam insulation that is applied directly to the roof sheathing, making this an un-vented, hot roof.

The *Icynene MD-R-200* insulation used is a water-blown foam insulation that also provides an air barrier. The vapour permeance of this

product, at 1.3 perms, is slightly higher than the current code limit. However, the lower perm drywall primer along with finished paint will provide the vapour barrier.

Once the exterior wall insulation was installed and taped, and two inches of spray foam insulation applied to the vaulted ceilings and transitional framing, we performed a blower door test to determine just how tight this approach can make the house. Air sealing an older house with some articulation can be challenging.

The existing 2x4 exterior frame walls are being insulated with the 2-pound Icynene spray foam, to make the exterior wall R-24.

Windows

The windows are triple-glazed, double low-e units manufactured by *All-Weather* windows.

One unanticipated challenge was related to the scheduling of work. Tasks are sub-contracted to specialty trades. Because windows are a particularly vulnerable part of the exterior envelope, window installation requires special attention. The contractor installs windows, while the exterior cladding is handled by a siding contractor. The siding sub-trade is also responsible for installation of flashings and all other exterior fittings.

This meant that the windows had to be installed before the siding contractor could get started with the installation of the rigid insulation. This led to extra cutting of the XPS and more joints that had to be sealed. This is something that may require some thought about scheduling tasks.

Space heating

The original combination heating system is being used, with adjustments for the new work being done. The primary heating unit, to replace the Lennox Completeheat heater that was a dud, will be a new *IBC* boiler unit.

IBC is a Vancouver company that manufactures very efficient, direct-vent gas fired wall-hung boilers. Their units have a wide 10:1 modulation range in the firing rate with an energy efficiency performance of 92.6% AFUE. Their base unit has a maximum capacity of 150,000 BTU/hr, which is large for many homes, and is often used in large custom homes, and in commercial applications, where maximum efficiency is achieved even in large demand applications by installing the units in series.

IBC has launched a new wall-mounted, condensing natural gas-fired Energy Star qualified boiler with a maximum output of 115,000 BTU/hr. The *SL 20-115* unit is rated at 95.1% AFUE. The units are manufactured from durable high-grade stainless steel, inside and out. Controls are built into the unit, and include outdoor reset control of water temperature, and built-in 3-load priority management and switching. There are multi-directional piping options.

The venting design allows layout flexibility as the maximum equivalent vent length is 100 linear feet for 2" vent pipe, and 240 equivalent feet for 3" vent pipe.

Energy Efficient Plumbing Options

The revised plumbing includes a drain water heat recovery unit. These units recover heat at time of use. These units are extremely simple, passive devices with no moving parts. As warm water from a shower or washing goes down the drain, replacement incoming water gets preheated by the drainwater heat recovery unit.

These units essentially are a simple copper coil wrapped around a section of copper drainpipe. The only condition is that these units must be installed vertically.

Drain water heat recovery units are inexpensive and have been approved for ecoEnergy and provincial incentives for some time. They have been tested for their energy performance, and are listed on NRCan's web site.

Unfortunately, some plumbing officials seem to be wary of any new technologies, and hide behind requirements for certification. We have been told that the unit we have installed (a Watercycles unit, manufactured in Saskatchewan) must have CSA certification. It doesn't seem to matter that there is no applicable CSA standard for these types of units, nor that they have been in use for some time even in this region, nor that federal and provincial incentives have been available for their installation for the past couple of years. We have heard from other builders that they chose the path of least resistance and do not install drain water heat recovery units because of the resistance offered by local officials.☼

Canadian Home Builders' Association

Technical Research Committee News

Annual Energy Consumption (kWh/yr)						
	Vancouver		Calgary		Toronto	
	4 ACH	2.5 ACH	4 ACH	2.5 ACH	4 ACH	2.5 ACH
No Mechanical Ventilation	22,363	22,106	35,359	35,035	29,649	29,562
Exhaust only, 60 cfm continuous	22,363	22,106	35,359	35,035	29,649	29,562
HRV @ 60 cfm continuous	21,413	20,525	34,724	32,754	28,887	27,391
HRV energy cost (kWh/yr)	- 950	- 1,581	- 635	- 2,281	- 762	- 2,171

Ventilation

A major concern today for many builders is whether or not heat recovery ventilators (HRV) should be mandated in the building code, as some jurisdictions are now requiring.

Ventilation is a health issue – we need to provide air change to maintain indoor air quality in the buildings we build. We consume about 50 pounds of air per person each day, so the quality of the indoor air is important to our health. At the same time, the air change introduces a heating load. Thus ventilation is a more complex issue than just whether or not a specific piece of equipment is used.

The latest Pulse survey had some questions on HRV use. It found that of the 80% of builders using balanced ventilation systems, more than 72% of respondents use HRVs in all their houses. When R-2000 and other builders involved with various premium labeling programs were extracted, this drops but still remains quite high. Most builders depend on HVAC contractors for the system design.

The impact that ventilation has on energy performance can be calculated. The attached table shows the impact of different ventilation strategies in three locations, assuming the houses are more or less airtight. For comparison, the same air change rate was assumed in all cases. The average new Canadian house is just slightly above 3 air changes at 50 Pascals, although this varies a bit from region to region. Manitoba has the tightest houses in Canada, typically coming in close to 2 air changes, while coastal BC has the loosest houses at around 4-5 air changes.

As homes become more airtight, mechanical ventilation becomes more important. Heat recovery on the ventilation does have net energy benefits, which are in addition to the benefits of healthier indoor air quality and better moisture management. It's these other benefits that are not always properly quantified. Some builders note added benefits as a result of fewer callbacks.

Asbestos in the Workplace

WorkSafeBC (the BC workers' compensation agency) has placed a major emphasis this year on asbestos handling. Renovators especially have been pressed to recognize and deal with asbestos in older homes. Recently, they have made presentations to various jurisdictions to try to make testing for asbestos mandatory prior to issuing permits. Although this is not going to happen, the industry has been put on notice that there is

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.
Canadian Home Builders' Association, Suite 500, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214
e-mail: chba@chba.ca
www.chba.ca

going to more vigilance placed on safe handling of materials containing asbestos.

Asbestos is a strong, fire-resistant mineral fibre. In the past it was used as insulation against heat or noise and for fire protection. It was also added to materials such as cement and plaster to give them more structural strength. Until the late 1980s, more than 3,000 products containing asbestos were used in house construction.

Asbestos fibers are carcinogens, and are the form of material that is of concern. The fibers must not be inhaled. Exposure to asbestos may significantly increase the risk for an individual, but it is something that could have an impact in the long term. However, it is important to recognize that although asbestos is a hazardous material, and must be handled safely, it is not the same as a toxic gas or fluid spill that has an immediate impact.

When demolishing or renovating older houses, there is a high probability of encountering materials containing asbestos, which may release asbestos fibers. Employers and owner/builders are responsible for ensuring the health and safety of all workers present at the workplace. They are also responsible for protecting the public.

All jurisdictions have regulations that must be followed that deal with handling and safe disposal of asbestos. In the Vancouver area, renovators now routinely do testing for asbestos before starting work, otherwise, if asbestos is discovered it could lead to more delays and expense.

EnerGuide Rating System Update

The EnerGuide Rating System (ERS) is increasingly being referred to in regulations, although the rating system was never designed as a regulatory tool. The system is being updated both technically and administratively to provide consumers and stakeholders with clear, easily understood, cost-effective home energy information through a national system. It will help Canadian homeowners, industry and stakeholders become "energy literate" regarding houses and the decisions related to them, and provide specific, readily accessible energy performance information to support decision making in designing, constructing, purchasing, renovating or operating a house.

The ERS will move from a single number (0 to 100) to a label that will show the energy consumption of the house (GJ/yr). This will provide a more realistic representation of energy use of the house, allowing comparison of all homes, regardless of type or location. The label will also include some information about the house – similar to a nutrition label on manufactured food products. This is expected to increase energy literacy somewhat.

The rating will provide visible evidence that good design matters. It will show that a large house, even if very energy efficient, uses a lot more energy than a small energy efficient house. Under the current scale, both could get the same rating even though they would actually have different energy loads.

For new homes, it will help position the house against the same house built to minimum code standards. The label will be supplemented with a Guide to the Label and a Homeowner Information Sheet that will include information such as a listing of data collected to rate the house, including airtightness, insulation levels, window sizes and performance, and mechanical system performance.

The administrative procedures are to be streamlined, with several options. The standard home evaluation will deal with basic data and include a blower door test. Optional add-on modules will provide value-added services that could include a renovation upgrade evaluation for existing homes, or a construction upgrade service for new homes and construction-phase blower door tests.

The draft ERS standard and protocols is being finalized and will be made available for public review this spring with the expected launch April 2012.☼

New Toilet Fixture Requirements in the BC Building Code

BC is taking another step toward increased water efficiency through new high-efficiency toilet (HET) and urinal requirements in the BC Building Code. Effective October 3, 2011, HETs (4.8 letre maximum flush) or dual-flush toilets will be required in new residential buildings or when renovations involving plumbing fixtures occur.

Dual-flush toilets are classified as HETs because the ratio of reduced flushes (up to 4.1 litres) to full flushes (up to 6 litres) results in an effective flush volume that is less than 4.8 litres. On average, high-efficiency toilets use at least 20 per cent less water than the 6-litre models that are currently required in BC.

Toilets and urinals represent 30 to 40 per cent of domestic water use in households and in commercial and institutional buildings. Installation of more efficient models results in significant water savings.

While some early low-consumption toilets did not perform well, in recent testing by Veritec Consulting, more than 100 high-efficiency models demonstrated good to excellent flushing performance. A full list is available on-line at *www.veritec.ca*

Code Interpretations: You Can Fight City Hall

Many have a feeling that you can't fight city hall – the path of least resistance is simply to give in to whatever the official in front of you says to do. A recent case in BC shows that you can fight city hall and win.

The issue that the homeowner pursued was how to construct a rainscreen.

The National Building Code of Canada requires a rainscreen for exterior cladding in high moisture areas. In BC, that includes all areas west of the Coast Mountains. The building code states that a minimum 10 mm wide capillary break is required between the siding and weather barrier/sheathing. The code does not prescribe how that gap is to be created. It recognizes that some structure is required, so the code states that 80% of the area must remain open. Wood strapping is one way of defining the rainscreen.

A number of manufactured rainscreen products have been introduced in recent years that are intended to provide the capillary break. A code appendix note states "products used to provide the capillary break include a variety of non-moisture susceptible, open mesh materials." These materials make it easier for builders to provide the required capillary break especially because for some cladding materials, wood strapping is difficult to use.

The building official should not be expected to assess anything beyond conformance with the measurable properties specified in the Code (i.e. does it provide a 10 mm gap, is it 80% open, does it allow drainage?). It is also important to note that there are no certification standards for materials that define a capillary break, so anyone insisting on a third-party certification for a capillary break product is out of line.

However, a number of jurisdictions in BC have ignored the code and insist that builders only use wood furring strips – disallowing any alternative way of defining the rainscreen despite an interpretive bulletin written by the Building Policy branch when the code changes were issued. (see Solplan Review No. 139 March 2008)

One homeowner in White Rock believed so strongly in the use of open drainage rainscreen materials rather than wood strapping that she took her case to the BC Building Code Appeal Board and won!

The building official insisted on strapping to provide solid backing for sidewall shingles, but the appeal board ruled that the attachment of cladding, including wood shingles, to sheathing through an intervening material providing a capillary break and conforming to requirements for a rainscreen is acceptable. A decision of the appeal board is project specific and binding on the parties. However, these decisions can set a precedent for all code users.

An interesting sidebar to this decision was a call your editor received recently out of the blue. The lady called to thank us for our article in Solplan Review 139. She attributed a major reason she won her case was because she used the article on rainscreen detailing. It seems she was doing research on the Internet, and came across the item that was reproduced, with our permission, on Jon Eakes' web site – Ask Jon Eakes: *www.joneakes.com.* Energy Answers

Building Code Appeal Board Decision #1690

http://housing.gov.bc.ca/bcab/search.htm

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Energy Answers

About 25 years ago you built an energy efficient house in Saskatoon. Whatever happened to it and what lessons could be learned from it?

Yes, a friend and I did build a house in 1985-86, and I believe it was the most energy efficient house in Saskatoon built that year. It featured R36 walls, R40 and R50 ceilings, an airtight envelope (.68 ac/h at 50 pascals), a heat recovery ventilator, passive solar orientation, and a relatively efficient heating system using a domestic water heater and a fan coil.

Figure 1. South side of the house before the deck was added.

A view of the R36 walls for the house is shown in Figure 3.

Figure 3. The house has triple glazed windows with R36 insulation. The skilled finishing carpenter cut the oak window sill from one piece of lumber. Note the tapered walls at the edge of the windows.

The good news is that the house continues to be energy efficient, and in spite of having tenants for the past 25 years, the heating system and the comfort levels are generally pretty good.

Here are a few of the lessons learned.

1. Centrifugal fans must run in the correct rotation.

Figure 2. North side of the house. Note how the attached garage was placed on the north side. Gravel was used for the driveway in anticipation of settlement of the backfill.

A few years ago the 1/3 hp split capacitor motor on the fan coil stopped working, and the motor was replaced. By mistake, the new motor was set up to run backward. The direct drive motor turns a centrifugal fan that normally blows about 450 litres/second to distribute the air to the rooms of the house. One of the characteristics of centrifugal fans is that they will still deliver some air even when the rotor is going in the wrong direction. I estimate that the fan with the motor running backward was only delivering about 1/3 as much heat as normal.

A good envelope in a house means a low heat loss. The house was able to stay warm throughout several winters even though the fan coil fan was running backwards.

The house was rented at the time, and the tenant thought that the heat output was slightly reduced and so he put some plastic over 4 of the openable windows. He figured that the heating coil in the fan coil was plugged with dirt, thus reducing the flow.

Anyway, I cleaned out the coil, which was somewhat plugged with dirt after 25 years of operation without cleaning, but the problem was not solved until I reversed the rotation on the fan coil fan. The fan coil should work for another 25 years.

2. A natural gas water heater has ample capacity for heating a house of this size and heat loss in a cold climate.

The HOT-2000 estimate of heat loss for the house was 22,000 BTU/hour. The 36,000 Btu/h water heater at about 75% combustion efficiency has enough capacity for both space and domestic water heating for this house even though our outside design temperature is -35 °C (-31°F) in Saskatoon.

Rob Dumont

Figure 4. The 36,000 BTU/hr induced draft water heater. Still running after 25 years. The fan coil is the white box mounted above and to the left of the water heater.

3. Changing anodes rods can extend the life of a glass-lined water storage tank.

The same water heater is running after 25 years. However, I have twice changed the anode rod in the unit. Magnesium anode rods cost about $25 plus installation of about $100. New gas fired water heaters in our area cost about $1000 to $1500 installed. These sacrificial anodes can greatly extend the life of glass lined steel tanks. Larry Weingarten, author of an authoritative book on water heaters, recently told me that he has seen a glass lined steel water heater last 50 years just by changing the anode rods periodically.

4. Even with a lot of people in a house using hot water, a 36.000 BTU/hour is enough.

For the last 18 years I have had the same set of tenants in the house. The family of 6 had 4 boys, and the house saw a lot of activity. However, not once did the tenants complain about insufficient hot water. I used low flow shower heads in the house, and also I did not put a night setback thermostat in the house. If a night setback thermostat had been used, there likely would not have been enough hot water in the mornings.

A house of that size has a thermal storage capacity from the gypsum board and wood members and furniture equal to about 25 megajoules per °C. If the house was set back 4 °C at night, it would take about 100 megajoules to reheat the house in the morning. As the water heater has only about 27 megajoules per hour of heat output, it would take a very long time in the coldest weather for the house to reheat.

Location of Heating Equipment

The heating equipment was located near the middle of the house on the lower level just under the BATH W/D room, as shown in Figure 5.

I put it there because someone said it was a good idea to locate a forced air furnace or fan coil system in the middle of the house so as to equalize duct lengths and pressure drops. This was a mistake. Because the fan coil, water heater, and the heat recovery ventilator are in the middle of the house, very long ducts must be used for the combustion air from outside, and also for the ducts bringing ventilation air to and from the heat recovery ventilator. For the HRV, the ducts are so long and poorly insulated (about R4 or R5), the incoming ventilation air is significantly preheated by heat pickup from the ducts which

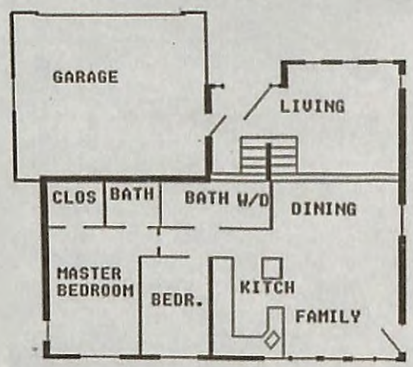

Figure 5. Floor plan for the upper floor

are about 7 metres long. As a consequence, the effectiveness and useful heat gain from the heat recovery ventilator is reduced.

Seal the ductwork

As part of a research study for NRCan, measurements were made of the amount of air leakage in the duct system for the fan coil.

The results were pretty bad. The fan coil normally puts out 450 Litres/second (957 cfm), but the actual amount of air measured at the room registers in the house was a low of 377 litres/second. In other words, about 16% of the air leaked out of the ductwork and 84% reached the registers. On the return air side, the leakage was even greater, as only 9% of the return air actually entered the return air grilles. All of the remaining air leaked through holes in the return air duct system.

One of the occupants of the house had noticed that a pool of cool air tended to lie on the floor in the lower level after the front door was opened during cold weather. As almost all of the return air flows into the leaky ductwork in the ceiling of the lower level, it is understandable that the return air system does not alleviate stratification of cool air on the lower level floor.

I later added another return air register at the floor level to help reduce stratification.

Fortunately all of the ductwork is inside the heated envelope for the house, and not in a crawl space or an attic where that air leakage would cause a lot of unnecessary heat loss and air exchange with outdoors.

Sealed combustion

In 1986 there were not a lot of energy efficient tank type water heaters. The unit I chose was one of the first induced draft water heaters on the market. It uses a fan on the top of the water heater to induce air flow through the center flue

on the heater. The exhaust is then vented through a stainless steel horizontal vent pipe. I once checked the water heater efficiency using a combustion meter, and the steady state efficiency was 76 %. The unit uses a pilot light (another no-no today as that light will burn about 6 to 8 million BTU a year) which further reduces efficiency.

Today there are several companies that produce sealed combustion water heaters with electronic ignition. These newer units also will condense and should have a high efficiency provided the return water temperature from the fan coil is below about 125 °F (52 °C).

Triple glazing

Over 25 years about half a dozen of the sealed triple glazed windows in the house had seal failures, and moisture was evident inside the glazing. I hired a person who was able to rid the windows of moisture. He drilled 6 mm diameter holes in the glass in the lower right and upper left parts of the windows. He then used a liquid solution to clean the glazing. After a week or so, when the moisture had dried out, he put filters in the 6 mm diameter holes. The technique is not perfect, as one of the windows still has some moisture in it, but the end result is pretty good. The cost was about 1/3 the price of new windows.

Shallow frost protected foundation

To allow more daylight into the lower level of the house, a shallow foundation was used. The foundation is only about 18 inches into the ground at the south side of the house.

In general, the foundation has performed pretty well. The R10 insulating skirt of extruded polystyrene effectively prevents frost penetration to the footings. Testing done by the National Research Council confirmed that the insulated skirt works very well. The skirt essentially stops the frost from getting near the footings, even though our average temperature in January is about -17°C. Some foundation movement has occurred on the southwest of the house, likely because of the spring runoff of melting snow from the park at the back of the house. This melting snow raises the water table and the silt and clay in the soil beneath the foundation has expanded a small amount.

Overall Energy Consumption

For a one year monitoring period in 1988-89 with three people in the house, the total energy consumption was 119 kWh/m² of floor area, 64% less than conventional 1970 houses in the same location. R-2000 houses in the prairies use approximately 150 kWh/m² per year. The natural gas consumption was 20,300 kWh, and the electricity consumption was 5,630 kWh for the one year monitoring period.

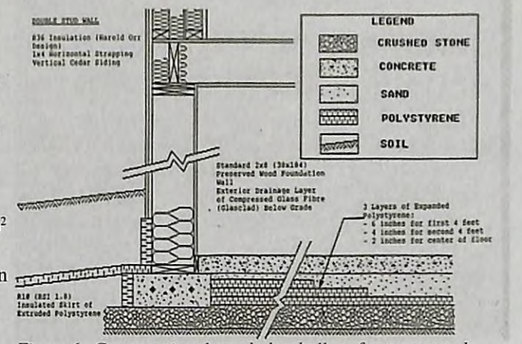

Figure 6. Cross section through the shallow, frost protected foundation. A crushed stone layer is used beneath the concrete footing. Pressure treated wood walls were used.

Costs

The construction cost in 1986 was $97,900, exclusing land. Since that time, additions added another $10,300 for a total construction cost of $108,300 excluding land. Over the years maintenance costs have averaged $770 a year, or about 0.7% per year of the original cost. This has been lower than the figure of 1% that is suggested in some books on maintenance.

Summary

The house energy system has performed well for 25 years with only minor problems. ☼

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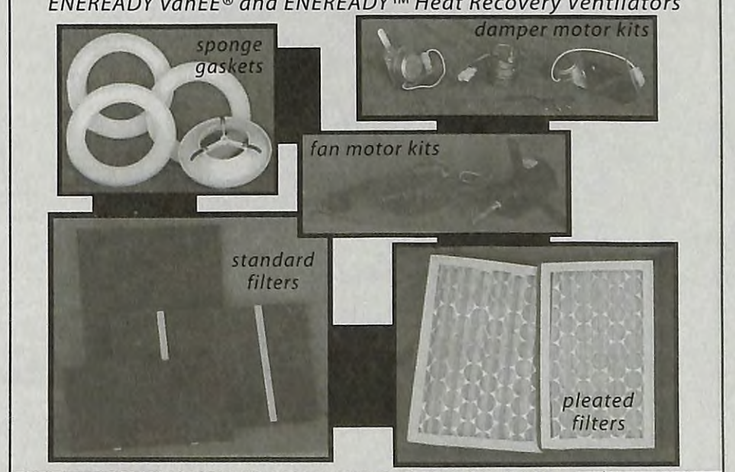

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Summary of NRC-IRC Housing Activities for 2010

By John Burrows

The NRC Institute for Research in Construction (NRC-IRC) engages in a wide range of research and technical activities in support of the housing sector. This article summarizes progress for 2010, based on a report prepared for the 2011 annual conference of the Canadian Home Builders' Association.

Building Envelope and Structure

A properly constructed building envelope is crucial to building performance and is an important area of study. Energy efficiency remains a dominant theme. As an example, NRC-IRC has been working to develop high-performance thermal insulation products that are eco-friendly (i.e. renewable, energy-efficient, biodegradable and indigenous). Further information is available at:
www.nrc-cnrc.gc.ca/eng/projects/irc/eco-insulation.html

Another energy-related project is investigating the performance of innovative, roof-integrated, photovoltaic (PV) products. This work is not only quantifying energy production potential, but will also investigate durability, air leakage, wind dynamics and resistance to water penetration. The results will be used to investigate the heat and moisture performance of these new roofing systems under a variety of climate conditions. They will also be used to benchmark an energy simulation model to predict whole-house energy performance at selected locations across Canada.

Research on innovative wall assemblies continued at the NRC-IRC Ventilation and Wall Research House. Researchers recently investigated the dynamic heat transmission and heat storage characteristics of two wall assemblies made with insulating concrete forms. They are now using the research house to study the performance of vacuum insulation panels, which have insulating values up to R-60 per inch. The objective of the project is to develop construction specifications and guidelines for assembling next-generation building envelope systems with the ultimate goal of encouraging their use. Details are available at:
www.nrc-cnrc.gc.ca/eng/projects/irc/innovative-systems.htlm

Keeping moisture out of buildings is a continuing challenge and a research project called *Window/Wall Interface Details for Managing Rainwater and Air Leakage* has been completed. Specific window/wall installation details were subjected to low temperature extremes and air leakage across the interface. Details are available at:
www.nrc-cnrc.gc.ca/eng/projects/irc/manage-rainwater.html

Indoor Environment

NRC-IRC's Indoor Environment program also addresses energy efficiency, as part of its research on ventilation and air quality. Researchers have begun exploring the potential to reduce household electricity use dramatically, perhaps to zero, during periods of system-wide peak demand. Among the possible means to achieve this are more efficient house designs, shifting demand to off-peak times with advanced controls, appliances and changes in occupant behaviour; and local power generation and storage.

For details, see: *www.nrc-cnrc.gc.ca/eng/projects/irc/zero-peak.html*

NRC-IRC continues to investigate indoor air quality issues and solutions. One study is developing test protocols for portable air cleaners (PACs), commercial air duct cleaning (DC) and heat/energy recovery ventilators (H/ERV). In 2010, researchers developed a test protocol for PACs that addressed their ability to remove airborne nano-particles as well as fine and coarse particles and volatile organic compounds (VOC), by-products emission, energy consumption, and acoustical properties. Reports and published papers for this project are available at:
www.nrc-cnrc.gc.ca/eng/projects/irc/air-initiative/iaq-solutions.html

A comprehensive long-term mould research project is proceeding. In 2010 a number of experiments were conducted to investigate mould growth on different construction materials in controlled static conditions. Using NRC-IRC's heat, air and moisture model, researchers conducted simulations to investigate the hygrothermal performance of specimens used in mould experiments under different conditions.

John Burrows is an Ottawa-based consultant and technical writer.

In a wide-ranging indoor air initiative, NRC-IRC is combining laboratory investigations of air supply, air distribution and air movement within residential buildings with a field study in the Quebec City area. Researchers are trying to determine whether an increase in air flows or air exchange rates will lead to an improvement in air quality. The objective of the field study is to improve the understanding of the impact of ventilation and air distribution on indoor air quality and the health of asthmatic children. Reports and published papers are available on the NRC-IRC web site at:
www.nrc-cnrc.gc.ca/eng/projects/irc/air-initiative.html

Traditionally, air supply registers for residential forced air systems have been located under windows to counteract the cold down draft from the window. However, new construction standards (well-insulated walls, better glazing and airtight wall/window interface) mean there is now less down draft. A new NRC-IRC project is running experiments to evaluate whether, in a new well-constructed building, the supply registers can be moved away from the traditional location without affecting indoor air quality, thermal comfort or energy loads.

Preliminary results indicate that, in terms of thermal comfort and air quality, there is no requirement to position supply air registers under windows for the heating season. Positioning the registers away from windows could have a large impact for builders as duct lengths could be shortened, saving materials and construction time. There would also be greater architectural freedom. Information on the research can be found at: *www.nrc-cnrc.gc.ca/eng/projects/irc/ci/v15no3/15.html*.

The complete Housing Activities Report will soon be available on the NRC-IRC Web site at:
http://nrc-cnrc.gc.ca/

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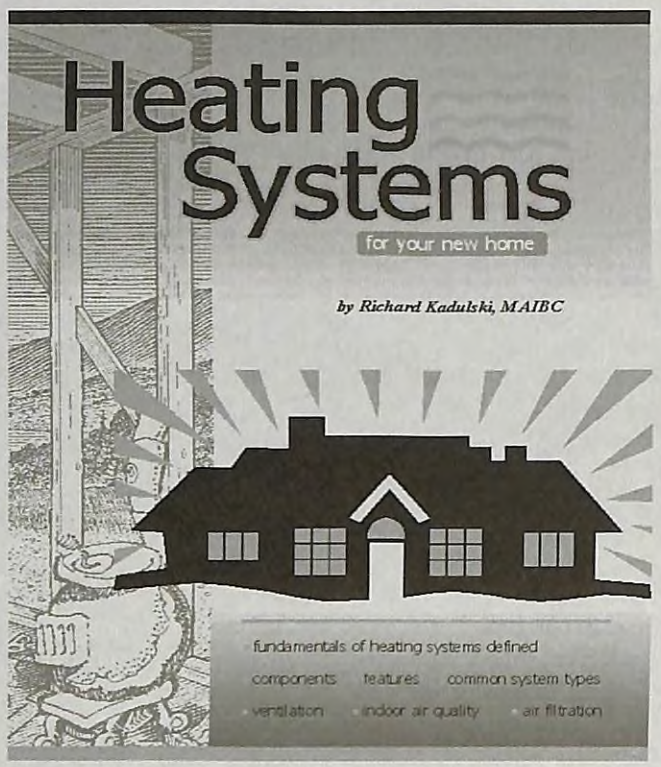

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